Experiences in Common Bean Research

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Introduction

The area of common bean production in Ethiopia is currently estimated at 250,000 to 300,000 hectares (CSA 2004). The export revenue from this commodity has reached USD 63 million annually, up from just over USD 2003 (Customs Authority, 2005), and the demand appears to be growing rapidly (Teshale et al, 2006). Common bean is consumed in traditional dishes, and the commonest forms of preparation of dry beans are nifro (boiled grain), mixed with sorghum or maize or with wasa and wat (local sauce) and with kocho. Fresh beans (mature and green pods) are also common as vegetable for local consumption and export. Common beans provide an important source of protein (22%), vitamins, and minerals such as Ca, Cu, Fe, Mg, Mn, and Zn for human diets, especially in developing countries (Broughton et al, 2003). In the first world countries the nutritional benefits and contribution of beans to healthy human diets is recognized by nonprofit organizations targeting human ailments like cancer, diabetes, and heart disease (Hangen and Bennink, 2003).

The wide range of growth habits among bean varieties has enabled the crop to be cultivated well under different agro-ecological conditions. Prostrate bush types in the central zone achieve rapid ground cover, compete well with weeds, and avoid competition with tef for labor. Climbers are widely grown on homestead fences in the western region, where they can make full use of the longer growing season. Some of them can also be fit for inter-cropping.

Early maturity and a moderate degree of drought tolerance have led to the crop's vital role in farmer's strategies for risk aversion in drought-prone lowland areas of central, eastern, and southern Ethiopia (Setegn
Farmers increase their bean area considerably in years when late onset of the rains prevent normal cereal establishment. This crop is better in escaping (short maturity period) drought than sorghum and in some years provides the only harvest in drought affected areas of the Rift Valley. In eastern Ethiopia, farmers practice varietals mixtures, which have helped to avoid disease and pest outbreaks. Soil erosion is relatively low under a bean crop canopy, and the straw is stored as a high quality supplement to cereal fodder during the dry season.

Conditions of Growth

Altitude and temperature

Common bean has a wide range of adaptation. In Ethiopia, common bean grows well between 1400 and 2200 m above sea level (Ohlander, 1980). The minimum and maximum mean temperature requirements are 10 and 32°C, respectively. Beans do not grow well at low altitudes as high temperatures cause poor seed set. At high altitudes, the growth is slow and beans are sensitive to frost (see Annex 1).

Rainfall

Areas with medium rainfall ranging from 350mm to 700mm (70 to 100 days) are good with a well-defined rainy season so that harvesting is done in dry weather. Some rain is required for the critical flowering period. Very high rainfall causes flower drop and increase the incidence of diseases. The relative humidity should not exceed 75%.
Soils

Beans can be grown on a variety of soils. It can be grown on light sandy soils to heavy clay soils if they are well drained, as beans are sensitive to water logging. pH should be above 5.0.

Variety Development

Germplasm Enhancement

During 1970s, local collections were made mainly from market samples and bean traders (Ohlander, 1980). These collections were tested with other introduced accessions from 1972 at Melkassa and other locations (see Annex 1). Initially the amount and diversity of locally collected germplasm were limited but after 1980s the number and diversity of germplasm was increased through introduction from exotic sources including recent climbing bean introductions.

Since 1995 introduction of germplasm was greatly increased in both number and diversity including climbing beans and snap bean and reached about 3258 accessions.

Accordingly, in the past three decades of research undertakings, greater than fifteen varieties were developed and released; appropriate crop management packages have also been developed and recommended (see Annexes 3 and 4). In addition, resistance sources of major diseases and insect pests were identified.
Cultural Practices

Land preparation
As beans have relatively bigger seeds, they do not need a fine seedbed. However, the land should be ploughed properly and should be free of weeds, soil clods and other undesirable materials. Plowing should be done just after harvesting the previous crop and before the soil is too hard to till. This operation will help to turn down the vegetation and the remains of the previous crop. A second plowing can be made one month later.

A third plowing can follow just before sowing. Pulverizing all soil clods with a hoe is also important.

Planting time
Time of sowing is very important. Delays in sowing reduce potential yield considerably. For any growing areas, the proper sowing time is when conditions are ideal for germination, emergence, establishment, and growth of bean. As they take 75-95 days to maturity at medium altitudes (1000-1700 m) and about 110 days at high altitudes (1800-2200 m), the sowing should be done about 70 days before the end of the rains at medium altitudes and about 100 days before the end of the rains at high altitudes. Too late sowing will lower the yield.

Important factor during sowing is depth of planting. Even if it is not possible to generalize 4 – 8 cm is the proper range to use depending on seed size, soil type, and climate. Under hot and dry conditions and rainfall is unreliable for deep sowing the seed should be given more protection from sun baking and places the seed in a possible advantage not to be induced to germination by light showers. However, such practice in areas of heavy soil and good rainfall results in poor
emergence. The seed can be row planted or broadcasted followed by subsequent plowing to cover the seeds.

Table 1: Research supported bean-planting time

<table>
<thead>
<tr>
<th>Production area</th>
<th>Rainy season</th>
<th>Planting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Ethiopia (lowland area)</td>
<td>3rd week of March</td>
<td>1st week of April</td>
</tr>
<tr>
<td>Southwestern</td>
<td>3rd week of April</td>
<td>2nd week of June</td>
</tr>
<tr>
<td>Central Rift Valley</td>
<td>3rd week of June</td>
<td>End of June to 2nd week of July</td>
</tr>
</tbody>
</table>

In the rest part of the country, mostly the planting time is from 2nd week of June up to 3rd week of July.

**Sowing method**

If possible, bean should be sown in rows for easier weeding. The row sowing can be done by hand or by a seed drill. It is also possible to sow by making a furrow with the local plough, seed in the furrow and cover with soil from the next furrow. If broadcasting is used the seed can be covered by plowing with an ox plough or by disc harrowing. Depending on seed size, soil type, and climate, the proper range for seed depth is from 4 to 8 cm.

**Seed rate**

Seed rate used depends on:

- seed size (expressed as 100 seed weight),
- row width, and
- intra-row spacing.

Spacing depends on the size of mature plant; both above ground and below ground, and how the land is used efficiently. Seed rate should be chosen to give about 300 to 500 thousand plants per hectare. To achieve this plant population a seed rate of 70 to 100 kg/ha is required for row planting and 110 to 120 kg/ha for broadcasting based on seed size and quality (see Annexes 2 and 3).
A higher seed rate should be used for broadcasting due to more uneven distribution of the seed and poorer field germination. For the Central Rift Valley, the spacing between rows should be 40 cm, and seeds in the row 10 cm apart. It is important to secure optimum plant population in beans at planting. Seed quality, soil moisture at planting, soil insects and/or seedling diseases are additional factors to be considered for optimum stand establishment.

Response to Fertilizers

Soil fertility is one of the bean production constraints in Ethiopia. The soils are generally deficient in N and P. Bean is responsive to N, P, and K fertilizer when soil levels are inadequate to support yield levels possible with existing soil moisture and growing season climatic conditions. Crop response to a nutrient is affected by soil moisture, temperature, placement, tillage, and crop. Thus, agronomists should know and give due emphasis to soil types, climate, and the bean plant itself. If other crops respond to phosphorus in the area apply around 50-100 kg DAP/ha during planting. The small amount of nitrogen will help the plants to get a good start. When the plants are deficient in nitrogen they show leaf yellowing, at this moment, 50-100 kg urea could be applied as top dressing before flowering.

Cropping System

Crop rotation
In Ethiopia, beans are grown in rotation with cereals (Imru Asefa, 1985). Growing of beans year after year on the same land will result in build-up of pests and diseases. Beans should preferably be not grown more often than every 3rd to 4th year on the same land.
Intercropping
Shade tolerance and early maturity contribute to the predominant position of beans as an under storey intercrop for sorghum, maize, coffee and enset in southern and eastern zones (85% of all sorghum in the eastern highlands is intercropped with beans). Beans can be interplanted with maize or sorghum in the same field either by broadcast planting the two crops together or by planting in different rows or by planting cereals in rows and broadcasting beans in between. This intercropping system not only improves the total productivity by 20% but can also reduce weed incidence and improve soil fertility. Early maturing bean varieties planted simultaneously with maize in two maize/1 bean intercrop pattern can give sustainable yield and income advantage in the rift valley (Niguse et al, 1995).

Double cropping
Double cropping with bean in eastern and southern zones has developed indigenously in response to land scarcity, and enable up to three crops to be obtained one of cereal and two of beans. Double cropping compensates for any yield reduction due to intercropping.

Alley cropping
Alley cropping of beans with perennial leguminous shrubs such as Sesbania sesban or Cajanus cajan (with 4 to 6 m between perennial hedge rows) can reduce soil erosion and also improve soil fertility. This system can produce an additional biomass of 2 to 3 t/ha, which can be used for fodder or for mulching or for green manure application without any significant grain yield reduction of beans.

Weed control
Beans do not compete well with weeds, particularly at early stage. Also weeding bean late in the season critically affects bean yields due to mechanical damage. Weeding is important and is made much easier if
the beans are sown in rows. For Bako areas, 80-100% yield loss due to weed was reported. Around Melkassa area, leaving beans unweeded can result in 37-64% yield loss based on soil types. The weeding can be started 2-3 weeks after sowing and continue to about 5 weeks after sowing.

To minimize the weed problem and increase the yield of beans weeding at least once around 30-35 days after emergence is ideal. Weeding should be finished before the flowering starts. If the beans are sown in rows weeding should preferably be done by hoeing with a light hoe or by using a row-weeder. Hand weeding will normally be the cheapest and most effective but if enough laborers are not available chemical weed control is possible. In that case use of herbicides such as alachlor (2.92 kg a.i./ha) or pendimethalin (1.50 kg a.i./ha) or flurodifen (2.0 kg a.i./ha) after sowing and before emergence of beans is recommended. In areas where perennial weeds such as Digitaria, Cynodon, Cyperus and Launea are a problem, one supplementary hand weeding might be very important.

**Crop Protection**

**Major Diseases and their Control**

Common beans suffer from a wide range of leaf, stem and root diseases including common bacterial (CBB), rust, anthracnose, angular leaf spot, floury leaf spot, web blight, halo blight, aschochyta (Phoma) blight and bean common mosaic virus ( BCMV). In Ethiopia CBB, rust and anthracnose are the most important and are widely distributed, while the others, though important, are much more restricted in their distribution (Habtu Asefa, 1990)
Common bacterial blight
Common bacterial blight caused by *Xanthomonas campestris*. Phaseoli is ranked among the most important diseases on bean in Ethiopia. It is most prevalent in the low altitude areas and at various degrees, wherever beans are grown. While this disease occurs, its prevalence varies within the same country and within season. The actual yield loss caused by this pathogen is estimated at 21%. The incidence and severity has been reported to be very high in many parts of the country. Estimated yield losses in United States, Canada and Colombia ranges between 13% and 60%. Though no immune variety is found, efforts are currently being made to produce varieties resistant or tolerant to these diseases.

**Symptoms**
Initial symptoms appear as water soaked spots on the lower surface of the leaves. As the spots enlarge, the centers become necrotic and irregular. Lesions later merge and surrounded by narrow, yellow zones, which turn brown. On pods small, water soaked, greasy- looking spots appear. These enlarge, becoming dark reddish brown and slightly sunken. Under humid conditions a yellow, slimy exudates may be produced, forming a yellow crust when dry. The Bacteria occurs on and inside seed, which may bear pale yellow lesions and become wrinkled or remain symptom less. Lesions may also develop on stems, which may break under windy conditions.

**Control**
Various methods of control have been tried for common bacterial blight. These include seed treatment with copper fungicides, cultural control methods such as crop rotation, deep ploughing, and disease free seed, and use of resistance varieties and dry weeding. Practically, it can be achieved for short-term control by use of disease free seed together with crop rotation but for long-term control, using resistant or tolerant varieties is effective. Recommended varieties such as Awash-1, Roba-1, Nasser, and Awash Melka are less affected by bacterial blights.
**Anthracnose**

Anthracnose is caused by *Colletotrichum lindemuthianum*, which is widespread and common, often causing severe damage. It is the most important disease of beans worldwide. Yield losses can reach 100%, especially when infected seed is used. Based on results in Tanzania, it has been estimated that, for each 1% in anthracnose 9 kg/ha reduction. The pathogen occurs in numerous pathogenic races.

**Symptoms**

Leaf symptoms appear initially on the lower leaf surface. Dark red to black lesions occur along the veins. On larger leaf veins, these lesions expand into sunken cankers, within which acervuli bearing conidia are produced. Lesions also commonly develop on cotyledons as well as on petioles, branches, stems, and pods. Pod lesions are typically sunken and contain masses of salmon-pink conidia, which are mostly cigar shaped.

**Control**

Use of healthy seed, rotation of two to three years and field sanitation (bean straw) are effective measures to control anthracnose in the field. Treatment of seeds with Benomyl (2.5g/kg of seed) and spray with Benomyl (0.4kg/ha) and Mancozeb (0.2% concentration) alternatively in 5 to 7 days interval from just before flowering to harvest. The spray will only pay in high value seed crops.

**Bean rust**

Bean rust caused by *Uromyces appendiculatus* is a widespread and important disease of beans in eastern and southern Africa. In Ethiopia, severe out breaks of bean rust were reported from the south and southwestern parts and the mid altitude and cooler regions. A severe outbreak of bean rust resulted in 85% yield loss in the popular and widely grown, but susceptible cultivar, Mexican 142 and 30% for the partially resistance Cultivar, 6-R-395. The loss depended on the
resistance level of cultivars, location, and season. These results related with the variation in yield and yield loss.

**Symptoms**
Minute yellow raised spots appear on both sides of infected leaves as well as on petioles and pods. These spots enlarge and rupture the epidermis to form reddish brown uredial pustules, which may be surrounded by yellow haloes and then by rings of smaller secondary pustules. The dry, powdery spores are typical of rust fungi. As the infection ages, much of the leaf becomes chlorotic while the tissue colonized by the fungus remains green (green islands). The pustules darken as the pigmented, thick walled, single called teliospores are produced and the gradually dies.

**Control**
Growing resistant varieties is a good control method. The recommended varieties have a good partial resistance against rust, especially Awash and Roba-1. Sanitation, crop rotation, and varietal mixtures are found to be very helpful control measures. Spraying mancozeb or systemic fungicides at different crop growth stage can be used as control measures.

**Angular leaf spot**
Angular leaf spot of beans is caused by the fungus *Phaeoisariopsis griseola*. It is found in tropical, sub tropical and temperate regions of the world. The fungus has numerous hosts, among them *Phaseolus vulgaris*, *P. Lunatus*, *P.acutifolius*, *Pisum sativum* and *Vigna sinensis*. It is widely distributed throughout the continent of bean growing areas.

**Symptom**
Initial symptoms of this disease are gray spots that generally appear on the lower leaf surface. Later on, these spots turned brown and covered with small columns of hyphae, called synnemata. Lesions are angular
because the leaf veins limit them. The angular lesions are also visible on the upper leaf surfaces; Lesions may cover large areas of the leaf, causing it to appear chlorotic. Occasionally, partial premature defoliation occurs. Lesions on the pods, stems, and petioles are reddish brown and frequently have darker borders.

**Control**
Plant debris and infected seed are the main sources of infection; wind, wind-driven rain, and soil are the principal means of dissemination. The use of clean seed, burial of infected debris, and rotation can decrease disease severity. However, in Africa the common practical measures are the use of cultivar mixtures and inter cropping with cereals. Although fungicidal seed dressings can also be effective, the use of resistant cultivars is the best strategy.

**Halo blight**
Halo blight, is caused by the bacterium *Pseudomonas syringae* PV. *Phaseolicola*, is a wide spread and important disease favored by cool conditions. The crop losses have not been adequately quantified in Africa. Losses up to 43% have been recorded elsewhere.

**Symptoms**
Initial symptoms appear three to five days after infection as small, water-soaked spots on the leaves. A halo of greenish Yellow tissue then develops around the lesion. Under epidemic conditions stems and pods may also become infected, the latter leading to seed infection. On the pods, the lesions are rounded with a greasy appearance and distinct halos.

**Control**
Host plant resistance is considered the most efficient control measures.
Web blight

The fungus *Thanatephorus cucumeris*, whose scelerotial state in *Rhizoctonia solani*, causes web blight, which is especially damaging under humid conditions. In the humid lowland tropics, losses of 90% have been recorded.

**Symptoms**

Leaf symptoms appear initially as small water soaked spots that seem scalded, lesions are grayish in color and are often surrounded by a dark-red border. Under humid conditions, the lesions develop rapidly and coalesce, leading to chlorosis, extensive blighting, and defoliation. The pathogen produces a dark mycelium by which the disease spreads through plant contact, as well as by the splash dissemination of basidiospores and sclerotia, which resemble a coarse brown dust on blighted plants. The fungus infects pods on which it produces small reddish brown lesions that can be caused a soft rot of the entire pod.

**Control**

Cultural practices such as mulching can be highly effective in suppressing web blight.

Bean common mosaic virus

**Symptoms**

Bean common mosaic virus (BCMV) may induce a variety of symptoms in systemically infected plants, including mosaic, green vein banding, leaf curling, secondary leaf malformation, and plant stunting. Certain strains of BCMV can induce a systemic necrosis reaction in mosaic resistance plants. This hypersensitive reaction, known as black root, appears first in the younger trifoliate leaves, which show a characteristic vein necrosis. The necrosis advances rapidly down the stem affecting the entire vascular system, including the pods (if formed) and roots. Symptom expression is dependent upon the bean genotype,
strain of the virus, environmental conditions, and growth stage of the plant at which it becomes infected. Generally, the younger a bean plan is infected, the more pronounced are the symptoms that develop. In addition, the seed transmissibility of BCMV decreases considerably when susceptible bean plants become infected after flowering.

**Control**
Use of healthy seeds and eliminates weeds and alternate hosts found grown nearby can be applied to control viral disease.

**Major Insect Pests and their Control**

**Bean Stem Maggot**
Ecological studies carried out so far show that three species of bean stem maggots (BSM)—commonly known as bean fly—occur in Ethiopia. These are *Ophiomyia phaseoli* (Tryon), *O. spencerella* (greathead) and *O. centrosematis* de Meijere. (Tsedeke Abate, 1990)

The adults are very small flies, about 2 mm in length. The larvae (maggots) are white and have a length of about 3 mm when fully grown. As soon as the seedlings have developed their primary leaves, deposition of eggs takes place on the leaf blades near petioles. The place, where an egg has been inserted under the epidermis appears as a sunken, light-colored spot, so that the base of the attacked leaves shows a characteristic speckling. The maggots mine through the leaf blade, petiole, and main stem to the base of the stem. There the feeding activity by the late larval stages causes a swelling with numerous cracks. Young plants attacked start withering, and usually will die within a short time. Pupation takes place in the crack of the swollen stem base. BSM is wide spread in Africa, Asia, and Australia. Attempts made to develop integrated management of BSM. These include cultural, host plant resistance, biological control, and insecticidal control.
Cultural control
Cultural control studies on management of BSM concentrated on the effect of sowing date and plant density. Sowing dates were site specific; for example, bean fly numbers were lower and crop yields higher in early sown beans in the drier areas of Mekelle, Kobo and Melkassa (Tsedeke Abate, 1990) where as at Hawassa, which has higher rain fall, bean fly numbers declined with late seeding. On the other hand lower bean fly numbers and higher yields were with higher plant densities of 300,000-500,000 seeds/ha at all locations.

Host plant resistance
Some varieties developed which are resistant to BSM (Beshbesh and Melke).

Chemical control
Seed dressing with endosulfan at the rate of 5 g a.i/kg of seed gave control of BSM.

Bean Bruchids (*Acanthoscelides obtectus*)
A serious stored products pest, adapted for life and reproduction in the dry conditions of produce stores, although many infestations may start in the field on the ripening seeds; it is multivoltine in produce stores on pulses. Most serious on Phaseolus beans, but it is recorded damaging many other different pulses in storage. Eggs are laid either loosely in the produce, or on the pods in the field, or in cracks in the beans testa; each female lays 40-60 eggs; hatching takes 3-9 days. Many infestations start in the field, and the larvae feed on the ripening seeds. Larval development through four instars takes 12-150 days.

The larvae are white, curved, thick-bodied, and legless and are found inside the bean seeds. Pupation takes place within a small cell inside the bored seed, behind a thin ‘window’ composed almost entirely of testa (for easy emergence of the adult); pupation usually takes 8-25 days.
Adults are small, 2-3 mm long, stout, brownish-black with pale patches on the elytra.

**Mexican bean beetle (Zabrotes subfasciatus)**
It is a major pest of beans in certain parts of the tropics. Even though, phaseolus bean is the usual host, the pest is also recorded on cowpea and other legumes. The pods are bored and the seeds eaten by the developing larvae. The eggs are laid stuck on to the pods or on the testa of beans, and the larvae feed on the cotyledons. The adult beetles are oval, small (2-2.5 mm), with long antennae. The hind femur is without spines, but there are two moveable spurs at the apex of the hind tibia. Attempts were made to develop IPM of bruchids.

**Control**

*Host plant resistance*
Research on host plant resistance has identified promising cultivars against Zabrates. Out of 100 CIAT accessions tested in the laboratory, several genotypes found to be highly resistant to Zabrates.

*Use of botanicals*
Neem, pepper tree, and Persian lilac give good control of Bruchids

*Chemical control*
Primiphos-methyl at the rate of 4-6 ppm a.i. gives effective control of Bruchids (Tsedeke 1984)

**Helicoverpa armigera**
The adult moth has a wingspan of about 35 mm and appears mainly in two color varieties with brown forewings or grey, respectively. The caterpillars are up to 40 mm in length and have a characteristic undulating, white band on each side of the body. Their color varies from black to green, brown, reddish-brown, whitish, and orange. The
caterpillars cause heavy damage to flower buds and pods. One caterpillar can damage a number of pods and buds by moving from one to the other.

**Control**
All crop residues must be burnt after harvest; strip cropping of 10-15 rows of bean with two rows of maize reduces ABW damage to beans. Planting of an early maturing maize variety (such as Katumani) about 10 days before planting common bean is recommended. Use of cypermethrin, applied at 150g a.i/ha gave effective control of ABW (Tsedeke and Adhanom, 1981).

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### Harvesting and Post-Harvesting

Beans can be harvested when all the pods are yellow. Early harvest of colored beans can cause discoloration. The plants are pulled out with the roots and this can preferably be done early in the morning when the plants are slightly moist as this minimizes shattering. The plants are stacked in the field until they are dry or brought to the threshing ground and stacked there for drying. The threshing can be done by oxen or by driving over the plants with a tractor. It can also be done by beating the beans with a stick. After threshing, beans can be cleaned by hand winnowing or by a winnowing machine.

As several diseases are carried over from one season to the next on the straw and chaff left in the field and on the threshing ground, a thorough sanitation should be carried out after the bean crop, i.e. all residues should either be fed to cattle within three months after harvest or be burned.
Effective seed program comprises many and diverse elements and activities, which must be coordinated to attain the principal objective of producing and distributing quality seed of improved varieties. Therefore, the success of a seed program is founded on producing and providing a sufficient quantity of good quality seed, at the required time, at reasonable cost, and at a location where it is needed, so that the majority of the farmers can enjoy the benefits provided by using this seed.

The principal objective is to provide useful information relating to the practices of production, quality control and processing of bean seed.

The quality of bean seed is very important because it greatly affects farmers’ yields. If damaged beans are used as seed, farmers may not get a good yield. Farmers usually select the best beans to use for planting.

Good quality bean seed

- has a high germination rate,
- is well dried,
- is pure: all seeds are the same variety and size,
- is clean: is not mixed with foreign matter like stones and dirt,
- is not damaged, broken, shriveled, moldy, insect damaged,
- is not rotten, and
- is not discolored
If you want to produce good quality bean seed, you should make sure that the seed meets these quality standards:

**Quality standards for bean seed**

- **Germination percentage**: 80% minimum
- **Moisture**: 13 - 15% maximum
- **Damaged seeds**: 0
- **Rotten seeds**: 0
- **Bean weevils**: 0
- **Faded (discolored) seed**: 10%
- **Foreign matter (cleanliness)**: 0

**Germination and purity**
The Germination percentage (rate) and purity can be measured by examining how many seeds out of the total have germinated and are of the same variety. If 80 seeds out of 100 germinate, the germination rate is 80%.

**Moisture content**
Determining the moisture of a bean seed is more difficult and requires more experience. Traditionally testing for seed moisture content is by biting with your teeth or by pinching between your fingers. The bean should be hard. If it is soft, it is too moist.

**Steps to produce quality seed**

**Select varieties to be multiplied**
The selection of the varieties that you will multiply is very important for determining your success. Multiply improved or local bean varieties that you think have a market.
Select seed for planting
Only plant clean, good quality bean seed of improved varieties obtained from a known source such as a seed project, or researchers since poor quality seed will result in a poor crop. For local varieties, find a source of good quality seed in your area.

Select the site where the seed will be grown
To ensure high bean yields, select highly productive land suitable for bean production. Avoid slopping and swampy land, very sandy soils, and areas with a lot of couch grass.

Prepare the land
Prepare the land early, dig or plough deeply, plough about one month before planting so that all organic material will be incorporated.

Plant the seed
Plant at the recommended seed rates, spacing, and appropriate planting time. If you are planting certified bean seed, put only one seed in each hole. Where as if the seed is obtained from other farmer or shops, plant 2-3 seeds in each hole.

Weeding and rouging
It is important to weed once each season. Remove or rogue out the diseased and plants that look very different in growth from the varieties you have planted by inspecting your field frequently.

Control diseases and insect pests

Harvest the seed
Only harvest plants, which are ready. Seed that is harvested too early will not produce healthy plants. When all leaves and pods of upright bush bean varieties are yellow, you know that the plants are ready for
harvesting. Harvest pods of climbing and trailing beans as they mature. Avoid harvesting late.

Post-harvest operations
These steps should be followed after harvesting:

Drying in pods
Before beans can be threshed, they must be dried in the pod. If you start threshing right after harvesting, you will damage the seed because it is too moist to be threshed. It is better to dry seed on a plastic sheet, or raised platform. Once you have prepared a place to dry the beans, follow these steps:

- Sort out weeds and immature pods,
- Arrange the pods loosely on the platform, or mat. If you put them too close together the air will not circulate and the beans will get moldy,
- Dry the beans for two sunny days, and
- Test the beans to see whether they are dry enough by breaking a few pods open and biting or pinching with your fingers.

Threshing
In threshing, it is important:

- Not to break and damage the seed,
- Not to mix the seed with dirt and trash, and
- Not to lose seed

Drying threshed seed
Threshed seed should be dried on mats, plastic sheets or wire mesh trays raised on a platform.

- Spread the seeds thinly on the drying surface to allow air to pass through it,
• Turn the seeds regularly avoid overheating,
• Dry the seeds for 1-3 sunny days,
• Take care to avoid the seed getting wet by rain or being damaged by domestic animals, and
• Test the beans to see whether they are dry enough by biting or pinching with your fingers.

Winnowing and sorting
Winnowing should be done to remove chaff, dust and other trash from the seed. After winnowing, remove shriveled, diseased, broken seeds and seed of other varieties by sorting.

• Measuring moisture content,
• Testing for germination,
• Treatment to protect it from damage by insects, rats and mould,
• Storing to keep seed clean and dry.

Seed storage
Storing the seed in a good way is to avoid damage and to keep its quality. The best way to do this is to make sure that you keep the seed clean and dry. Seed must be dry before it is packaged and stored. Proper drying reduces the chance of mould. The moisture content during storage time should not be greater than 13-15%. Make sure that any container used to store the seed is clean and disinfected. Once you have put the beans in sacks or other containers, they should be stored in a clean, dry, and well-ventilated place. Make sure that the storage place you use has no leaks. Rainwater should not run down the walls of the storage place. Close all holes and opening where rats, insects and water can get in.
References


Customs Authority. 2005. Annual progress report (not published)


Annex 2: Classification of bean producing agro-ecologies and production areas

<table>
<thead>
<tr>
<th>AEZ</th>
<th>Regions</th>
<th>Production system</th>
<th>Production constraints</th>
<th>Specific purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2</td>
<td>Jijiga</td>
<td>Irrigation</td>
<td>Moose stress, common bacterial blight, bruchids,</td>
<td>Cash/ Food</td>
</tr>
<tr>
<td>SM1</td>
<td>Kobbo, Mieso Babile</td>
<td>Mono-crop, meher</td>
<td>Weeds, low N and P, Moisture stress, Bruchids, CBB, rust and anthracnose, lack of food varieties, bean stem maggot, flower beetles</td>
<td>Cash</td>
</tr>
<tr>
<td>SA2</td>
<td>Ziway</td>
<td>Mono-crop, meher</td>
<td>Weeds, low N and P, Moisture stress, Bruchids, CBB, rust and anthracnose, lack of food varieties, bean stem maggot, flower beetles</td>
<td>Cash</td>
</tr>
<tr>
<td>SM2</td>
<td>East Shewa, Tigray</td>
<td>Mono-crop, meher</td>
<td>Weeds, low N and P, Moisture stress, Bruchids, CBB, rust and anthracnose, lack of food varieties, bean stem maggot, flower beetles</td>
<td>Cash</td>
</tr>
<tr>
<td>SH2</td>
<td>West Hararghe</td>
<td>Inter-cropping in sorghum/maize/chat, meher and belg</td>
<td>Diseases, weeds, Shattering, Bruchids, Erosion, varieties compatible with inter-cropping system</td>
<td>Food + Cash + Feed</td>
</tr>
<tr>
<td>M2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH1</td>
<td>Wolkietie</td>
<td>Mono-crop, inter-crop, meher</td>
<td>Bean stem maggot, weeds, low plant density, low soil fertility, rust, bruchids, land scarcity, varieties</td>
<td>Mostly Food</td>
</tr>
<tr>
<td>SH2</td>
<td>North Omo</td>
<td>Mono-crop, inter-crop, meher</td>
<td>Bean stem maggot, weeds, low plant density, low soil fertility, rust, bruchids, land scarcity, varieties</td>
<td>Mostly Food</td>
</tr>
<tr>
<td>M1</td>
<td>South Omo</td>
<td>Mono-crop, inter-crop, meher</td>
<td>Bean stem maggot, weeds, low plant density, low soil fertility, rust, bruchids, land scarcity, varieties</td>
<td>Mostly Food</td>
</tr>
<tr>
<td>SH2</td>
<td>Bako Jima</td>
<td>Bush + climber, inter-cropping, meher</td>
<td>Wild animals, angular leaf spot, floury leaf spot, anthracnose, bruchids, draft power, staking, termites</td>
<td>Food</td>
</tr>
<tr>
<td>M1</td>
<td>Pawe</td>
<td>Bush and climber, meher, mono-crop</td>
<td>Wild animals, angular leaf spot, floury leaf spot, anthracnose, bruchids, draft power, staking, termites</td>
<td>Mostly Food</td>
</tr>
<tr>
<td>SH1</td>
<td>Abobo, Assosa</td>
<td>meher, intercrop, mono-crop</td>
<td>insect pests, varieties</td>
<td>Mostly food as dry bean or the leaf as vegetable</td>
</tr>
<tr>
<td>H1-2</td>
<td>Konso</td>
<td>Inter-cropping</td>
<td>varieties compatible with inter-cropping, low N and P</td>
<td>Mostly food</td>
</tr>
</tbody>
</table>
Annex 3: Summarized information on released bean varieties for local consumption

<table>
<thead>
<tr>
<th>Variety</th>
<th>Year of release</th>
<th>Days to maturity</th>
<th>Yield on station (g/ha)</th>
<th>Seed size</th>
<th>Seed Rate (kg)</th>
<th>Suitable area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roba-1</td>
<td>1990</td>
<td>75</td>
<td>21</td>
<td>Small</td>
<td>90-100</td>
<td>Across all locations (environments)</td>
</tr>
<tr>
<td>Attendaba</td>
<td>1997</td>
<td>74</td>
<td>24</td>
<td>Medium</td>
<td>90-100</td>
<td>Central Rift Valley</td>
</tr>
<tr>
<td>Zebra</td>
<td>1998</td>
<td>76</td>
<td>27</td>
<td>Medium</td>
<td>80-90</td>
<td>Central Rift Valley</td>
</tr>
<tr>
<td>Brown Speckled</td>
<td>1997</td>
<td>78</td>
<td>11</td>
<td>Large</td>
<td>90-100</td>
<td>Across all bean growing environments</td>
</tr>
<tr>
<td>Beshbesh</td>
<td>1997</td>
<td>76</td>
<td>25-30</td>
<td>Small</td>
<td>70-80</td>
<td>Specific for Southern region (Wolaite area) (for bean fly resistance)</td>
</tr>
<tr>
<td>Red Wolayta</td>
<td>1974</td>
<td>77</td>
<td>22</td>
<td>Small</td>
<td>90-100</td>
<td>Across all bean growing environments</td>
</tr>
<tr>
<td>Melke</td>
<td>1977</td>
<td>78</td>
<td>20-25</td>
<td>Large</td>
<td>70-80</td>
<td>Across all bean growing environments</td>
</tr>
<tr>
<td>Novak</td>
<td>2003</td>
<td>88</td>
<td>23-25</td>
<td>Small</td>
<td>80-90</td>
<td>Across all locations (envelope)</td>
</tr>
<tr>
<td>Dimu</td>
<td>2003</td>
<td>86</td>
<td>20-23</td>
<td>Small</td>
<td>80-90</td>
<td>Across all locations (envelope)</td>
</tr>
<tr>
<td>Goberashia</td>
<td>1998</td>
<td>88</td>
<td>20-23</td>
<td>Large</td>
<td>70-80</td>
<td>South eastern (Jimma area)</td>
</tr>
<tr>
<td>Kassowe</td>
<td>1998</td>
<td>90</td>
<td>20-23</td>
<td>Large</td>
<td>80-90</td>
<td>South eastern (Jimma area)</td>
</tr>
<tr>
<td>Gedo</td>
<td>1997</td>
<td>91</td>
<td>23</td>
<td>Medium</td>
<td>80</td>
<td>East and West Hararghe</td>
</tr>
<tr>
<td>Tabier</td>
<td>1998</td>
<td>92</td>
<td>22</td>
<td>Medium</td>
<td>70</td>
<td>Harassa area (South)</td>
</tr>
<tr>
<td>Wedo (mane-41)</td>
<td>2003</td>
<td>93</td>
<td>21</td>
<td>Large</td>
<td>90</td>
<td>Wedo</td>
</tr>
<tr>
<td>Melka Dimma</td>
<td>2006</td>
<td>91</td>
<td>23</td>
<td>Medium</td>
<td>80</td>
<td>Central rift valley and similar environments</td>
</tr>
<tr>
<td>Batacopia</td>
<td>2005</td>
<td>91</td>
<td>23-30</td>
<td>Medium</td>
<td>80</td>
<td>Inlet altitudes of Sidama and Wolaita zone</td>
</tr>
<tr>
<td>Angha</td>
<td>2004</td>
<td>96</td>
<td>22-28</td>
<td>Medium</td>
<td>60</td>
<td>Barko, Bifobocho, Loko and similar areas</td>
</tr>
<tr>
<td>Tiko</td>
<td>2003</td>
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<td>23-30</td>
<td>Medium</td>
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<td>Barko and Tiko</td>
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<td>Ibadu</td>
<td>2003</td>
<td>92</td>
<td>22-28</td>
<td>Medium</td>
<td>60</td>
<td>Central rift valley and similar areas</td>
</tr>
<tr>
<td>Omo-95</td>
<td>2006</td>
<td>100</td>
<td>20-32</td>
<td>Medium</td>
<td>50-70</td>
<td>All bean growing areas of eastern Hararghe</td>
</tr>
<tr>
<td>Bobe Red</td>
<td>2006</td>
<td>92</td>
<td>25</td>
<td>Medium</td>
<td>80</td>
<td>Central rift valley and similar areas</td>
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</tbody>
</table>
Annex 4: Agronomic, yield and agro-ecological information's on small white (navy) bean varieties (export type).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Year released</th>
<th>Sowing date</th>
<th>Seed rate (kg)</th>
<th>Fertilizer rate (kg/ha)</th>
<th>Maturity date</th>
<th>Yield (g/ha)</th>
<th>Agro-ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Broadcasting</td>
<td>Raw planting</td>
<td></td>
<td>On station</td>
<td>On farm</td>
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<tr>
<td>Mexican-142</td>
<td>1972</td>
<td>Late June to early July</td>
<td>100-120</td>
<td>90-100</td>
<td>50 kg urea</td>
<td>95-100</td>
<td>15-20 10-15  All over the country</td>
</tr>
<tr>
<td>Awash-1</td>
<td>1990</td>
<td>Late June to early July</td>
<td>100-120</td>
<td>90-100</td>
<td>50-100 kg DAP 50 kg urea</td>
<td>95-100</td>
<td>20-24 15-20 Central rift valley</td>
</tr>
<tr>
<td>Awash Meika</td>
<td>1998</td>
<td>Late June to early July</td>
<td>100-120</td>
<td>90-100</td>
<td>100 kg DAP 50-100 kg urea</td>
<td>95-100</td>
<td>22-25 18-20 All over the country</td>
</tr>
<tr>
<td>Argene</td>
<td>2005</td>
<td>Late June to early July</td>
<td>100-120</td>
<td>90-100</td>
<td>46 kg DAP 50 kg urea</td>
<td>85-90</td>
<td>20-22 15-20 Central rift valley and similar areas</td>
</tr>
<tr>
<td>TA04JI</td>
<td>2005</td>
<td>Late June to early July</td>
<td>100-120</td>
<td>90-100</td>
<td>46 kg DAP 50 kg urea</td>
<td>85-90</td>
<td>22-25 19 Central rift valley and similar areas</td>
</tr>
<tr>
<td>Chore</td>
<td>2006</td>
<td>Late June to early July</td>
<td>100-120</td>
<td>90-100</td>
<td>46 kg DAP 50 kg urea</td>
<td>87-109</td>
<td>23 All over the country</td>
</tr>
<tr>
<td>Cherecher</td>
<td>2006</td>
<td>June-may</td>
<td>60</td>
<td></td>
<td>46 kg DAP 50 kg urea</td>
<td>98</td>
<td>22-28 21-27 All bean growing environments</td>
</tr>
</tbody>
</table>